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(54) Method of starting electric machines

Verfahren zum Anlaufen einer elektrischen Maschine

Méthode de démarrage d'une machine électrique

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(56) References cited:
EP-A- 0 193 708 **WO-A-90/00325**

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Description

[0001] This invention relates to a method of starting three phase electric machines. The invention is particularly, though not exclusively, applicable to switched reluctance (SR) machines.

[0002] The switched reluctance drive is a variable-speed drive system comprising an electric motor supplied from a power-electronic converter under the control of low-power control electronics. The motor has salient poles on both the stator and the rotor, typically with an excitation coil around each stator pole. These stator coils are grouped to form one or more phase windings. The electrical currents in the windings are typically switched on and off by power-electronic switches.

[0003] The timing of the switching of the currents in the windings is controlled in relation to the relative angular position of the stator and rotor poles. This relative position may be detected by a rotor position transducer which consists of a rotating member and stationary sensors which supply signals to the control electronics. In single and two-phase systems only a single sensor is required, but motors with more than two phases generally use more than one sensor according to the prior art.

[0004] Figure 1 shows a schematic diagram of a typical 3-phase SR motor, which has six stator poles and four rotor poles. The poles carrying coils A and A' have opposite magnetic polarisation. Phases B and C are formed similarly.

[0005] A rotor position transducer (RPT) is used to ensure that the currents of the phase windings are switched on and off at the appropriate angles of rotation. Figure 2a illustrates a typical system consisting of a rotating slotted disc and three optical sensors which are switched by the rotation of the disc.

[0006] Figure 2b shows the idealised variation of the inductances of the phase windings as functions of angle of rotation θ. Positive torque is defined as that which acts in the direction to move the rotor in the direction of positively increasing θ. Such torque is produced by any phase when the winding of that phase carries current and the angle of rotation is such that the inductance is increasing with increasing θ. Negative torque is produced when a phase carries current during that part of its inductance cycle where the inductance is decreasing with increasing θ (or increasing with decreasing θ).

[0007] It will be apparent therefore that for normal positive torque operation in the direction of increasing θ (the forward direction) each phase is energised in turn when its inductance is increasing. Figure 2b also shows the three output signals of the sensors according to prior art. In general the RPT consists of three sensors, which may for example, be optical, magnetic or inductive, which cooperate with a rotating member, for example a disc with cut out slits, to produce signals such as those shown in Figure 2b as RPT_A, RPT_B and RPT_C. Thus the signal RPT_A changes from zero to a positive value at the centre of the minimum inductance region of phase A and returns to zero at the maximum inductance position of phase A. The signals RPT_B and RPT_C behave in the same manner for phases B and C respectively. It will be clear that whether the rotor is starting from rest in either the forward or backward direction or running in either direction, the RPT signals enable the control electronics to excite the appropriate phase winding over the appropriate angle of rotation to produce torque in the desired direction.

[0008] The torque developed by the motor may be controlled at low speeds by adjusting the magnitude of the current in the phase windings over the fixed angle defined by the respective positive or negative RPT signals depending on the desired direction of torque. At high speed the torque is normally controlled by adjusting the angle over which a phase winding is switched onto the power supply and the angle with respect to the inductance cycle at which the switching on takes place, i. e. by timing the switching on and off of the phase energisation with reference to the RPT signals. It will be clear from Figure 2b that the combined RPT signals can be used to determine the rotor position to one sixth of a phase period thus giving a 15 degree resolution. For more refined control of switching angles, each of these six regions can be interpolated, for example, by using a high frequency pulse train which is phase locked to the low frequency RPT signals as described in GB 1597790 (Stephenson).

[0009] US 4990843 (Moren) describes a method by which the three detectors of Figure 2a may be replaced by a single detector. The rotating disc incorporates six or twelve slots, giving a sensor signal which has respectively a rising or falling edge every 30 degrees of rotation, or a falling edge every 30 degrees of rotation, which may be used to switch the phase winding currents of the motor. However, the method suffers from the serious disadvantage

[0010] That correct tracking of the relationship between edges and phases may be lost due to electrical noise, for example, in the sensor signal.

[0011] EP-B-0193708 (Byrne) discloses a two-phase variable reluctance machine drive. The rotor is initially positioned by simultaneous excitation of adjacent phases. However, continued rotation on start-up is carried out by exciting both of the phases according to various alternative sequences.

[0012] There is no disclosure in Moren or Byrne of continuing rotation of the rotor by energising and de-energising one of the phase windings according to the monitored position.

[0013] It is an object of the invention to provide start-up procedures for electric machines using position information from a rotor encoder.

[0014] The present invention provides a method of starting a polyphase electric machine as defined in the accompanying independent claim. Preferred features are recited in the dependent claims.

[0015] By 'phase induction cycle' is meant the inductance of the machine as seen from the terminals of the or each phase winding. The phase inductance cycle is a function of rotor position and varies cyclically within the rotor cycle between given inductance values, for example inductance maxima or minima.

[0016] The encoder is conventionally a discate member mountable on a rotor shaft. The features may influence the sensor magnetically, by means of a Hall effect; through light transmissive/non-transmissive parts or light reflective/absorbing parts, by capacitive or inductive effects or by other known means.

[0017] Preferably, the method includes switching one of the phases of the machine thereafter to cause rotation of the rotor between angular positions at which the said switched phase can further rotate the rotor.

[0018] It may be necessary to develop a suitable motor speed before polyphase control of the motor can be initiated.

[0019] In this case this 'single phase' start-up running of the motor according to the invention may be effected for more than one cycle of the rotor until the rotor speed allows the rotor position to be accurately determined at any position.

[0020] The present invention can be put into practice in various ways some of which will now be described by way of example with reference to the accompanying drawings in which:

Figure 3 is a timing diagram for the rotor position sensor output;
Figure 4 is a timing diagram for starting a rotor;
Figure 5 is a timing diagram of a modification of the starting procedure according to the invention;
Figure 6 is a circuit diagram of a motor control circuit for a switched reluctance motor; and
Figure 7 illustrates an encoder.

[0021] Referring to Figures 6 and 7, a control system for a switched reluctance motor comprises a rectifying and smoothing circuit 10 which receives an a.c. mains input. The smoothed rectified d.c. output from the circuit 10 is applied to a power convertor 12 which provides a three phase switched supply for a 6 stator pole/4 rotor pole, 3 phase switched reluctance motor 14 as shown in Figure 1. The power convertor comprises a set of phase power switches such as electronic power transistor switches which gate the supply of d.c. current to the 3 motor phases.

[0022] A rotor position sensor 16 is arranged at the periphery of a shaft encoder 18 mounted to rotate with the rotor shaft 19 (see Figure 7). The sensor 16 may be a Hall effect sensor or an optical sensor. The encoder is formed with a sequence of features of marks and spaces 20,22. In the case of a Hall effect sensor these may be constituted by a sequence of lands and recesses which are respectively closer to and more distant from the sensing face of the sensor 16 or a sequence of coded magnetised regions in the path of the sensor. In the case of an optical sensor there is also a light source and the marks and spaces may be respectively constituted by light absorbing and light reflecting parts or light passing slots and light blocking castellations. Of course, other forms of sensor, such as a capacitance sensor, could be used to equal effect.

[0023] The signals from the sensor are transmitted to a microprocessor-based controller 24. Based on the information received from the sensor, the feedback from 'the power switches in the form of phase current sensing signals and the drive commands from the user, the controller 24 issues signals to the power switches. It will be appreciated by the skilled person that other forms of controller are contemplated, such as a hardwired logic controller.

[0024] The single detector method overcomes the problem of loss of tracking in the prior art. The falling edges (i.e. the trailing edges producing a low output from the sensor) in this system are used to give more information on actual position and direction of rotation. For example they may be placed at either ¼ or ¾ of the distance between adjacent rising edges thus producing either a short or a long pulse respectively as the rotor rotates. These short and long pulses may be spaced around the disc in a repeating pattern consisting of six pulses corresponding to one phase period. The phase period repeats every 90° of the encoder. The pattern chosen may be 'LLSSLS' where L = long pulse and S = short pulse. To give binary numbers for the decoding logic, a long pulse may be decoded as a '1' and a short pulse decoded as a '0'. This gives an output code sequence of '110010' which continually repeats as the disc is rotated past the sensor. The sequence of circumferential marks and spaces in the encoder of Figure 7 is a reproduction of the sequence 110010 according to this convention. Although a 6-bit code is used, 3-bits is adequate to create a code to identify the rotor position with sufficient resolution within the phase period. The additional redundancy in the 6-bit sequence allows more reliable error checking.

[0025] When the rotor is rotating, the code may be read in with the last six bits being stored. The code may be updated when each rising edge is received. The state of the received code then gives the position of the rotor to within one sixth of a phase period, as for the original three-detector system. Figure 3 shows the example sensor code in relation to the maximum and minimum inductance positions for the three phases. It will be clear that the code could be positioned with any 15 degree orientation in relation to the phase inductances.

[0026] While the code sequence is arranged to repeat on the encoder every phase inductance cycle in this embodiment, i.e. once per rotor pole, the position information could be derived from a longer code spanning up to the complete circumference of the encoder disc. However, the shorter sequence coinciding with the phase inductance cycle provides all the information for position and timing necessary while keeping the sequence period as short as possible without ambiguity.

[0027] The position of the rotor as derived from the code sequence may be compared with the position determined by counting, from a known initial position, the rising edges of the sensor signals as in the basic system. The code repeats itself and is fed serially into a shift register within the controller. Therefore, the constant monitoring of the code allows the controller to determine the rotor position according to the state of the sequence in the shift register. If a full correct code is received then it may be assumed that this gives the correct position. If this position also matches the counted position, correct operation is confirmed. If it does not match the counted position, it may be assumed that an error has occurred and the counted position may be updated to coincide with the position defined by the code sequence, thus detecting and correcting the error. The drive should then continue to work normally by counting the rising edges. If, however, no correct code is available from the sensor input (e.g. if the code has been corrupted by electrical noise), the drive may continue to operate by counting the rising edges or may be switched off and allowed to coast until a correct code sequence is received.

[0028] If the direction of rotation is to be reversed, the sensor output may be inverted to keep the evenly spaced edges as rising edges. The received code will then be the same as in the forward direction, but in a different angular position relative to the stator poles. The starting of the drive (discussed later) and the reading of the code will be the same as for the original direction of rotation, but the conversion from the code input to the three detector equivalent outputs, i.e. the sequencing of the three phases, will be different.

[0029] To decode the output of the sensor one looks at the mark/space ratio of the incoming signal at every rising edge and determines if the last pulse was long or short. If the pulse was long then it may be decoded as a one and if it was short to decode it as a zero. The decoded bit may then be input to the shift register of six bits length so keeping a record of the recent history of the sensor output, the state of the sequence being a reflection of the rotor position. A simple way to decide if the pulse is long or short is to count the time for which the signal is high and the time for which it is low and then to compare them. If the time were counted by a fixed rate clock, then the clock rate would have to be high to achieve a good resolution at the top speed. This would require a large number of bits to enable the system to operate at the lower speeds. For this reason a clock rate may be used which is frequency-locked to the (angularly evenly spaced) rising edges of the RPT input.

[0030] It was noted above that operation of the single-detector system required knowledge of the initial position of the rotor at starting. A known initial position may be achieved as follows. If any one phase is excited for a time, the rotor will usually be pulled into approximate alignment with the maximum inductance position of that phase. Alternatively, if two phases are simultaneously excited for a time, the rotor may be pulled approximately to the position between the two maximum inductance positions at which the positive and negative torques of the two phases balance each other. It is possible that the initial rotor position will occasionally correspond to an undesired zero-torque position and the rotor will therefore fail to be pulled into the desired alignment. Failure to pull in to the desired initial position will probably result in failure to start correctly. This condition may be detected and the motor stopped and restarted.

[0031] If such a false start cannot be tolerated, it may be avoided by following an initialisation sequence, for example by energising first one phase alone and then the two phases together. The desired position may correspond 'to one of the transition edges of the RPT signal, i.e. at the boundary of a 15 degree region. In practice, the rotor may come to rest at either side of this transition. However, the correct phase switching sequence on starting can be assured by noting whether the signal is high or low, i.e. in which of the 15-degree regions the rotor is positioned.

[0032] The system described allows full starting torque in either direction of rotation. The system can be simplified for drives which require only modest starting torque and in which the ratio of friction to inertia is not high. This development will now be described.

[0033] Figure 4 illustrates the sensor output and phase energisation for the simplified system. The detector signal transitions may occur in this example at the maximum and minimum inductance of phase A and this signal may therefore be used to control directly the energisation of phase A. The initial rotor position is assumed in Figure 4 to have been established with both phases A and C energised. Phase C may then be switched off causing the motor to accelerate in the forward direction due to the torque produced by phase A. Phase A is switched off at its position of maximum inductance and the motor then coasts with zero developed torque until phase A is again switched on at the next rising edge of the transducer signal. Thus, one phase is switched directly according to the rising and falling edges of the sensor output. Once the rotor is underway it runs up as a single-phase machine until the motion of the rotor is sufficient for the motor control to establish itself.

[0034] There will be a lower limit on the rate of the rotation of the rotor below which the polyphase control is not possible. Once this speed is exceeded and a correct code sequence or sequences have been received, the position of the rotor relative to the stator can be determined and polyphase control according to the invention effected. It is clear that, to ensure starting, the energy imparted to the rotor over the relatively short initial energisation of phase A must be sufficient to carry the rotor against the friction and load torque through more than 45 degrees to the next energisation of phase A. Phase A may then be energised for a full 45 degrees. The motor accelerates in this manner, with only phase

A being energised, until a sufficient speed is achieved for reliable timing of energisation of phases B and C from the transducer signal.

[0035] It will be clear that the motor may be started in the reverse direction of rotation if the initial rotor position is established with phases A and B energised and if the transducer signal is inverted. The coded rotating member has been positioned so that in the example phase A is initially excited. Repositioning of the member would allow either phase B or C to be the initially excited phase.

[0036] The severity of the restriction on starting torque is reduced by modifying the system according to the 1 invention as follows. The transducer coded disc is modified to give a signal as illustrated in Figure 5, i.e. with a mark:space ratio of 1:2, with the rising edges corresponding to the maximum inductance of phase A and the falling edge to the maximum of phase B. The rotor may be initially positioned with phases A and C energised as before. Starting is initiated by turning off phase C, leaving A energised. At the sensor edge, phase A is turned off. Up to this point the arrangement is unchanged, with the same amount of energy being imparted to the rotor as in the unmodified system. However, as phase A is turned off, phase B is turned on. The rotor continues to rotate to the aligned position of phase B, when B is turned off, and it will then coast to the next RPT signal edge.

[0037] This arrangement gives a higher initial pulse of energy to the rotor before coasting, and after the aligned position of B is reached, the drive will run up using phase B only. Note that only 30 degrees of the B phase region is used for such operation.

[0038] The specific example described above is a 6/4-pole, 3-phase motor drive. In this case the code sequence repeats itself four times in the rotor cycle to coincide with the number of rotor poles. For a different number of rotor poles a corresponding number of repetitions of the code sequence can be used so that the position of the rotor from a known start-up position can be determined. Of course, a single sequence for the rotor cycle can be used. However, the delay before a complete cycle has been read may be too long. It will be clear that the invention may be used for motors with other pole combinations and with phase numbers other than three. It will also be clear that the invention may be used for generators as well as motors. The RPT detector may use optical, Hall-effect, inductive or other means.

Claims

1. A method of starting a three phase electric machine (14) comprising a rotor, a stator having three phase windings (A/B/C), a rotor position encoder having a 1:2 mark/space ratio and being mounted to rotate with the rotor, and a sensor having an output which is influenced by the encoder, the encoder having angularly spaced features each with an angular period equal to that of the rotor poles, successive transitions in the output of the sensor coinciding with positions of maximum inductance of first and second phases of the machine, the method comprising: energising the phase winding of the first phase of the machine so that the rotor assumes a predetermined position; de-energising the first phase winding; energising the winding of the second phase such that the rotor rotates towards a maximum inductance position of the second phase; monitoring the passage of the rotor past the stator according to the said transitions in the output of the sensor; de-energising the second phase winding at a moment that assists in allowing the rotor to freewheel past the said maximum inductance position of the second phase according to the transitions in the output of the sensor; and continuing rotation of the rotor by energising and de-energising the second phase winding according to the transitions in the output of the sensor.

2. A method of starting a three phase electric machine (14) comprising a rotor, a stator having three phase windings (A/B/C), a rotor position encoder having a 1:2 mark/space ratio and being mounted to rotate with the rotor, and a sensor having an output which is influenced by the encoder, the encoder having angularly spaced features each with an angular period equal to that of the rotor poles, successive transitions in the output of the sensor coinciding with positions of maximum inductance of first and second phases of the machine, the method comprising: energising the phase windings of the first and the third of the phases so that the rotor assumes a predetermined position; de-energising the third phase winding leaving the first phase winding energised; de-energising the first phase winding; energising the second phase winding such that the rotor rotates towards a maximum inductance position of the second phase; monitoring the passage of the rotor past the stator according to the said transitions in the output of the sensor; de-energising the second phase winding at a moment that assists in allowing the rotor to freewheel past the said maximum inductance position of the second phase according to the transitions in the output of the sensor; and continuing rotation of the rotor by energising and de-energising the second phase winding according to the transitions in the output of the sensor.

Patentansprüche

1. Verfahren zum Starten einer Dreiphasen-Elektromaschine (14), mit einem Rotor, einem Stator mit drei Phasenwicklungen (A/B/C), einem Rotorpositionsencoder, der ein 1:2-Zeichen-Pause-Verhältnis hat und zur Drehung mit dem Rotor montiert ist, und

mit einem Sensor mit einem Ausgang, der durch den Encoder beeinflusst wird, wobei der Encoder winkelig beabstandete Merkmale hat, jedes mit einer winkeligen Periode, die gleich der der Rotorpole ist, wobei aufeinanderfolgende Übergänge am Ausgang des Sensors mit Positionen maximaler Induktivität von ersten und zweiten Phasen der Maschine zusammenfallen, wobei das Verfahren umfasst: Einschalten der Phasenwicklung der ersten Phase der Maschine, so dass der Rotor eine vorbestimmte Position einnimmt; Ausschalten der ersten Phasenwicklung; Einschalten der Wicklung der zweiten Phase, so dass sich der Rotor in Richtung auf eine maximale Induktivitätsposition der zweiten Phase dreht; Überwachen der Verlagerung des Rotors entlang des Stators gemäß den Übergängen am Ausgang des Sensors; Ausschalten der zweiten Phasenwicklung zu einem Zeitpunkt, der es unterstützt, dass sich der Rotor im Freilauf an der maximalen Induktivitätsposition der zweiten Phase vorbeidrehen kann, und zwar gemäß den Übergängen am Ausgang des Sensors; und Fortsetzen der Drehung des Rotors durch Einschalten und Ausschalten der zweiten Phasenwicklung gemäß den Übergängen am Ausgang des Sensors.

2. Verfahren zum Starten einer Dreiphasen-Elektromaschine (14), mit einem Rotor, einem Stator mit drei Phasenwicklungen (A/B/C), einem Rotorpositionsencoder, der ein 1:2-Zeichen-Pause-Verhältnis hat und zur Drehung mit dem Rotor montiert ist, und mit einem Sensor mit einem Ausgang, der durch den Encoder beeinflusst wird, wobei der Encoder winkelig beabstandete Merkmale hat, jedes mit einer winkeligen Periode, die gleich der der Rotorpole ist, wobei aufeinanderfolgende Übergänge am Ausgang des Sensors mit Positionen maximaler Induktivität von ersten und zweiten Phasen der Maschine zusammenfallen, wobei das Verfahren umfasst: Einschalten der Phasenwicklungen der ersten und der dritten Phase, so dass der Rotor eine vorbestimmte Position einnimmt; Ausschalten der dritten Phasenwicklung, wobei die erste Phasenwicklung eingeschaltet bleibt; Ausschalten der ersten Phasenwicklung; Einschalten der zweiten Phasenwicklung, so dass sich der Rotor in Richtung auf eine maximale Induktivitätsposition der zweiten Phase dreht; überwachen der Verlagerung des Rotors entlang des Stators gemäß den Übergängen am Ausgang des Sensors; Ausschalten der zweiten Phasenwicklung zu einem Zeitpunkt, der es unterstützt, dass sich der Rotor im Freilauf an der maximalen Induktivitätsposition der zweiten Phase vorbeidrehen kann, und zwar gemäß den Übergängen am Ausgang des Sensors; und Fortsetzen der Drehung des Rotors durch Einschalten und Ausschalten der zweiten Phasenwicklung gemäß den Übergängen am Ausgang des Sensors.

Revendications

1. Procédé de mise en marche d'une machine électrique triphasée (14) comprenant un rotor, un stator ayant trois enroulements de phase (A/B/C), un codeur de position de rotor ayant un rapport marque/espace de 1:2 et étant monté de manière à tourner avec le rotor, et un capteur ayant une sortie qui est influencée par le codeur, le codeur ayant des éléments angulairement espacés chacun d'une période angulaire égale à celle des pôles du rotor, des transitions successives dans la sortie du capteur coïncidant avec des positions d'inductance maximum des première et deuxième phases de la machine, le procédé comprenant: l'excitation de l'enroulement de phase de la première phase de la machine de telle sorte que le rotor adopte une position prédéterminée; la désexcitation du premier enroulement de phase; l'excitation de l'enroulement de la deuxième phase de telle sorte que le rotor tourne vers une position d'inductance maximum de la deuxième phase; la surveillance du passage du rotor au-delà du stator selon lesdites transitions dans la sortie du capteur; la désexcitation du deuxième enroulement de phase à un moment qui contribue à permettre au rotor de tourner librement au-delà de ladite position d'inductance maximum de la deuxième phase selon les transitions dans la sortie du capteur; et la poursuite de la rotation du rotor par l'excitation et la désexcitation du deuxième enroulement de phase selon les transitions dans la sortie du capteur.

2. Procédé de mise en marche d'une machine électrique triphasée (14) comprenant un rotor, un stator ayant trois enroulements de phase (A/B/C), un codeur de position de rotor ayant un rapport marque/espace de 1:2 et étant monté de manière à tourner avec le rotor, et un capteur ayant une sortie qui est influencée par le codeur, le codeur ayant des éléments angulairement espacés chacun d'une période angulaire égale à celle des pôles du rotor, des transitions successives dans la sortie du capteur coïncidant avec des positions d'inductance maximum des première et deuxième phases de la machine, le procédé comprenant: l'excitation des enroulements de phase de la première et de la troisième phases de la machine de telle sorte que le rotor adopte une position prédéterminée; la désexcitation du troisième enroulement de phase en laissant le premier enroulement de phase excité; la désexcitation du premier enroulement de phase; l'excitation du deuxième enroulement de phase de telle sorte que le rotor tourne vers une position d'inductance maximum de la deuxième phase; la surveillance du passage du rotor au-delà du stator selon lesdites transitions dans la sortie du capteur; la désexcitation du deuxième enroulement de phase

à un moment qui contribue à permettre au rotor de tourner librement au-delà de ladite position d'inductance maximum de la deuxième phase selon les transitions dans la sortie du capteur; et la poursuite de la rotation du rotor par l'excitation et la désexcitation du deuxième enroulement de phase selon les transitions dans la sortie du capteur.

FIG.1.

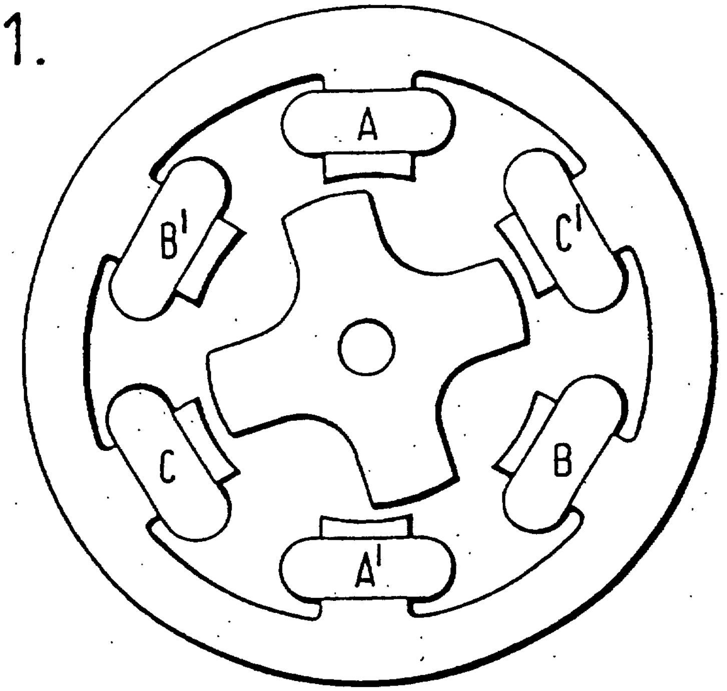
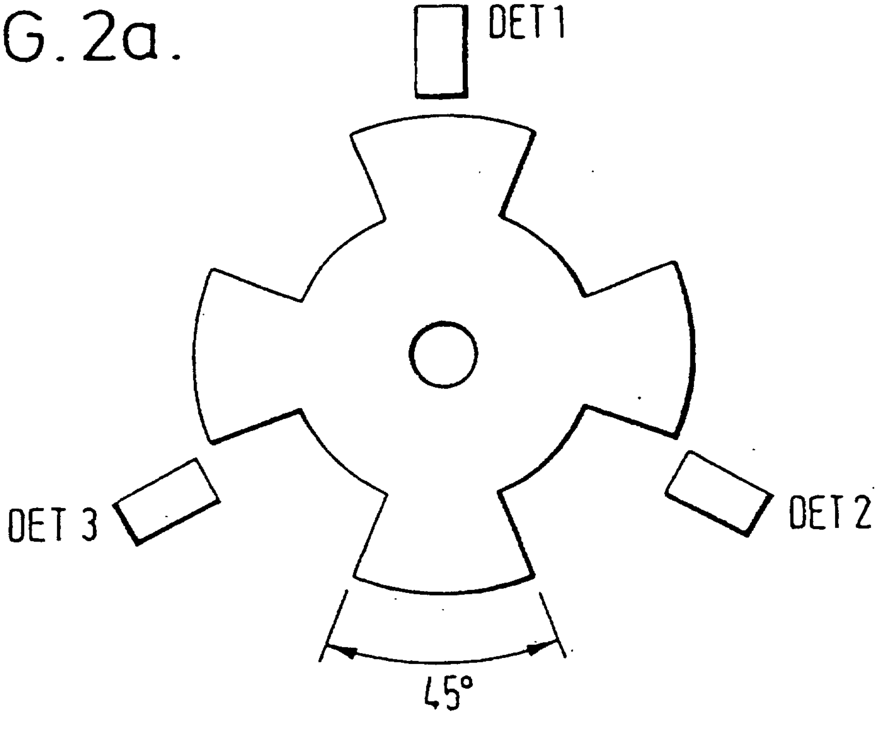


FIG.2a.



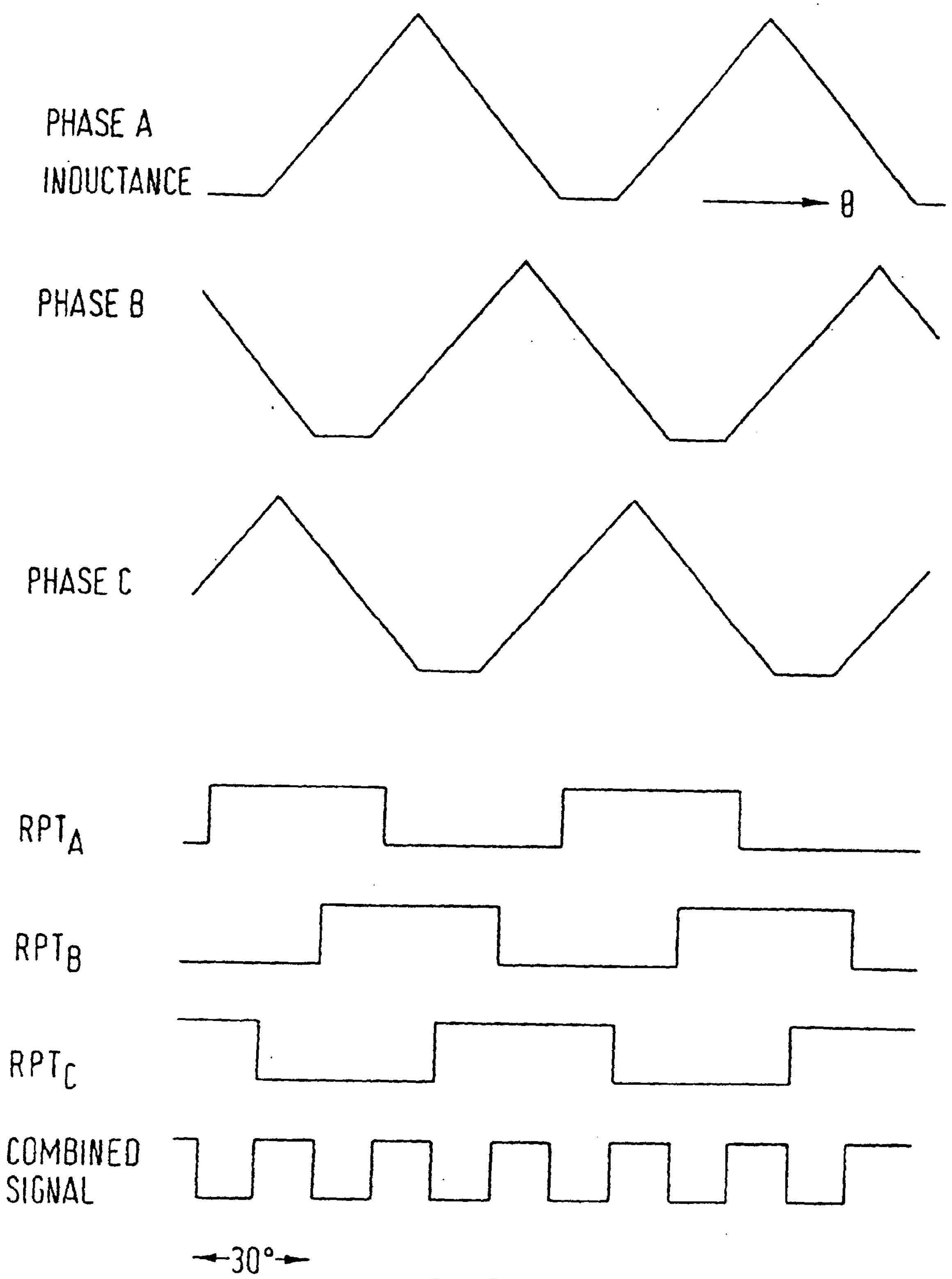

PHASE A
INDUCTANCE
θ
PHASE B
PHASE C
RPT$_A$
RPT$_B$
RPT$_C$
COMBINED
SIGNAL
30°

FIG. 2b.

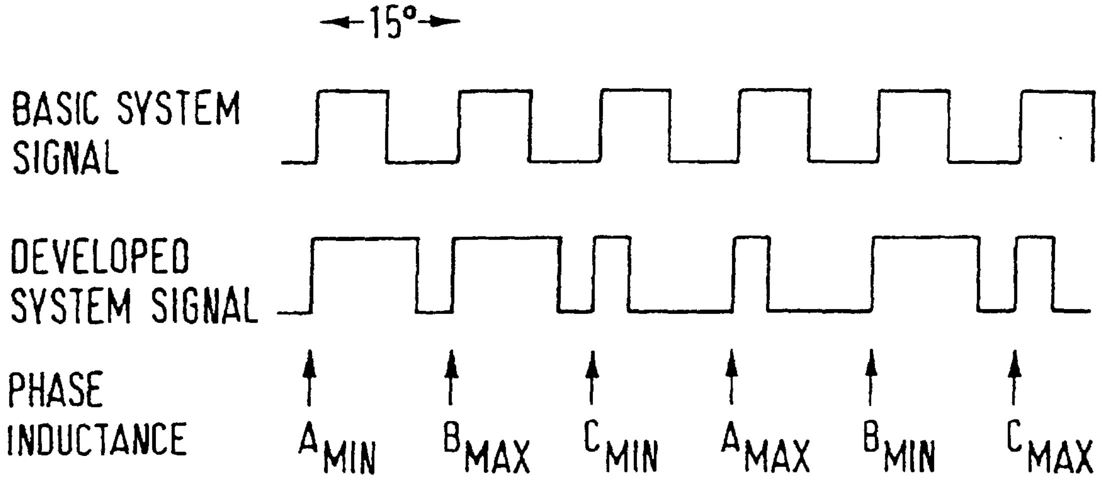

15°
BASIC SYSTEM SIGNAL
DEVELOPED SYSTEM SIGNAL
PHASE INDUCTANCE
A MIN
B MAX
C MIN
A MAX
B MIN
C MAX

FIG.3

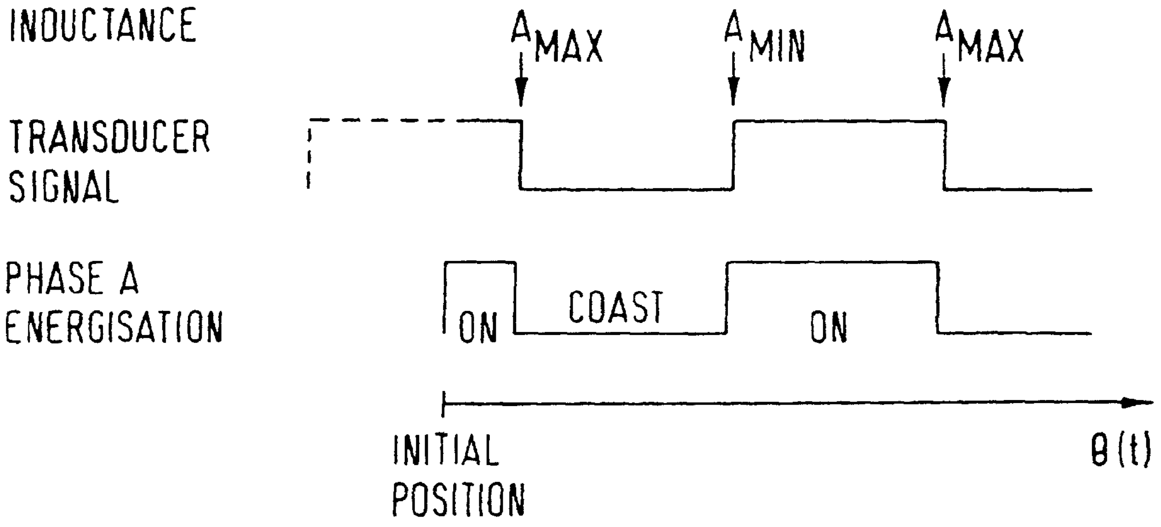

INDUCTANCE
A MAX
A MIN
A MAX
TRANSDUCER SIGNAL
PHASE A ENERGISATION
ON
COAST
ON
INITIAL POSITION
θ(t)

FIG.4.

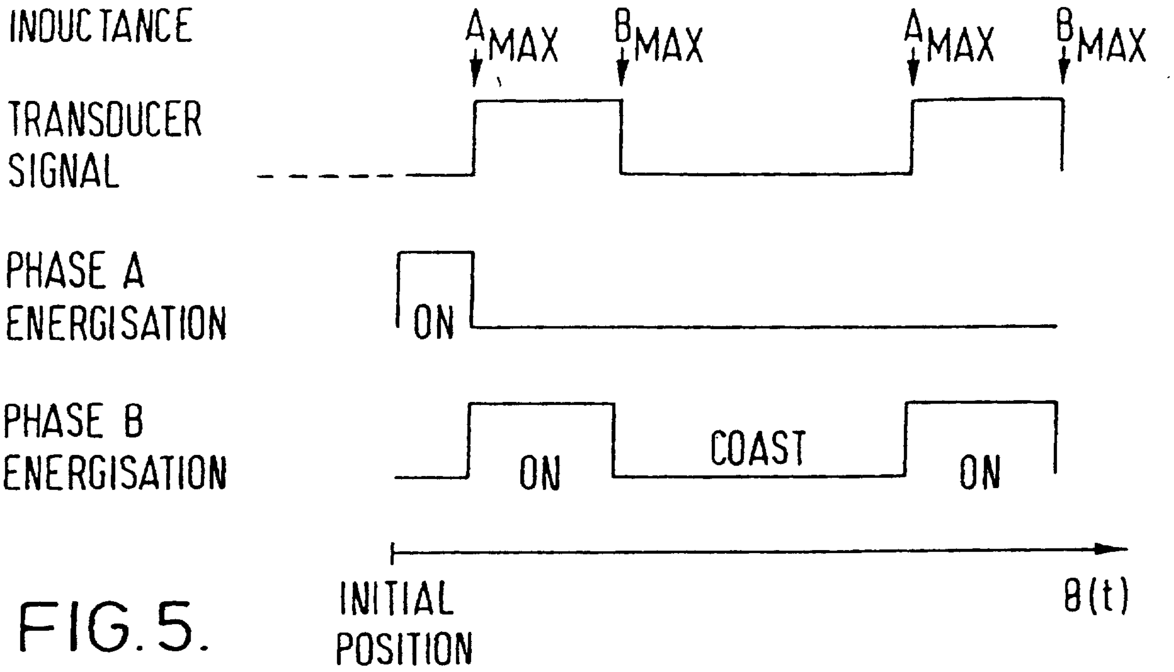

INDUCTANCE
TRANSDUCER SIGNAL
PHASE A ENERGISATION
PHASE B ENERGISATION
A MAX
B MAX
A MAX
B MAX
ON
ON
COAST
ON
INITIAL POSITION
θ(t)

FIG.5.

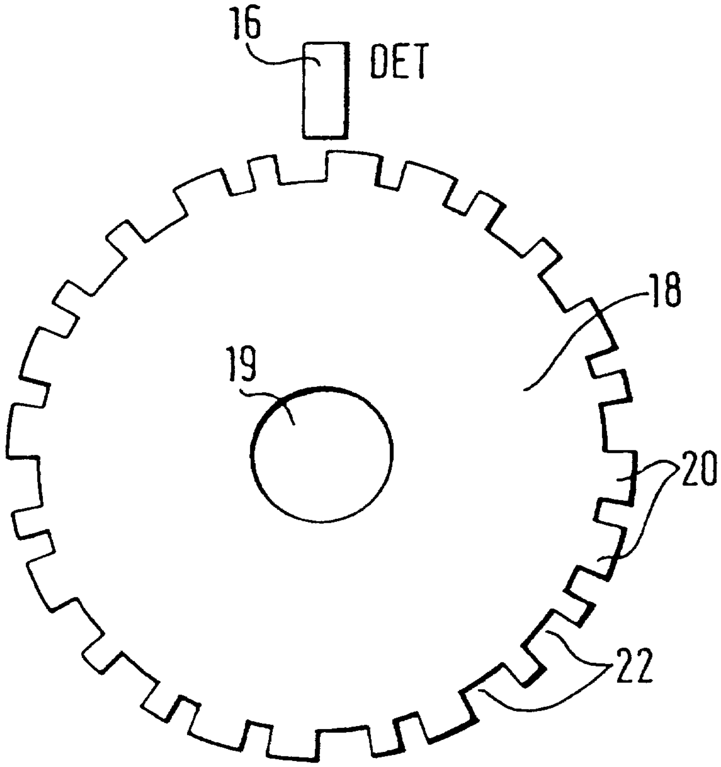
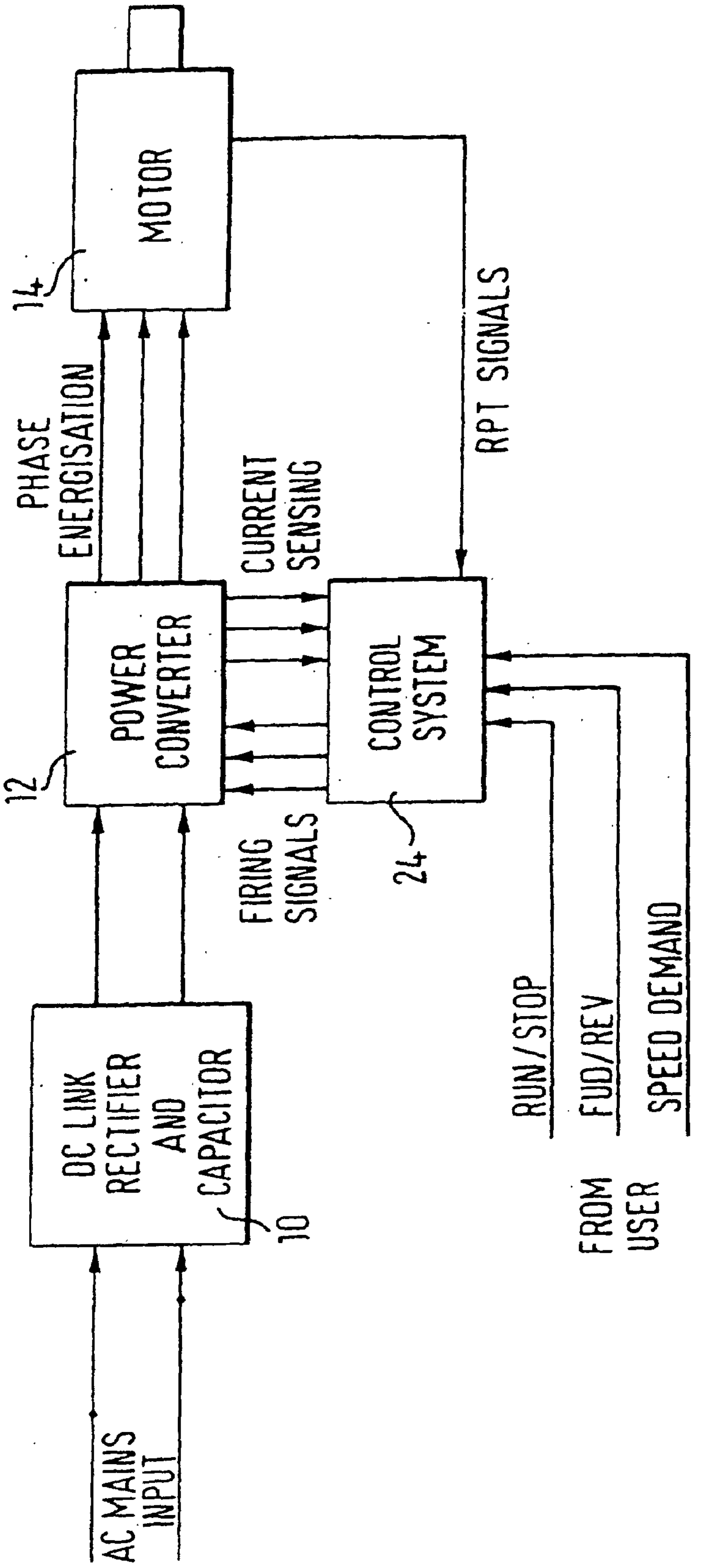

16
DET
18
19
20
22

FIG.7.

FIG.6.


AC MAINS INPUT
DC LINK RECTIFIER AND CAPACITOR
10
12
POWER CONVERTER
PHASE ENERGISATION
14
MOTOR
CURRENT SENSING
FIRING SIGNALS
CONTROL SYSTEM
24
RPT SIGNALS
RUN/STOP
FUD/REV
SPEED DEMAND
FROM USER